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ABSTRACT

This three-part monograph examines the major price indexes used to measure the intensity of inflation. The first part discusses the recent behavior of prices as measured by the Consumer Price Index (commodities, goods, and services), the Producer Price Index (wholesale prices of crude materials, intermediate materials, supplies, components, and finished goods), and the Implicit Price Deflator for the Gross National Product (GNP). The severity of the current inflation problem and the importance of good measures of price changes are emphasized. The second part explains the concept of a price index, reviews the criteria that a good index must satisfy, and discusses conceptual and statistical problems of design and construction. The final part describes characteristics and explains recent revisions of each of the indexes. The Consumer Price Index, revised in 1978, is noted as having the most effect on daily business decisions throughout the country. Prices are observed in 85 areas and separate indexes are computed in 28 cities. The oldest continually published measurement, the Producer Price Index, covers about 2800 commodities. Finally, both previously discussed indexes are explained in terms of their influence on the Implicit Deflator Index for the GNP in which consumer expenditure of the GNP is adjusted for price change. (Author/KC)

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MEASURING PRICE CHANGES:

a study of the price indexes

by

William H. Wallace and
William E. Cullison

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Introduction

Inflation has been one of the dominant economic problems in the United States since 1965. Inflation's intensity is usually measured through indexes that are designed to reflect changes in the general level of prices. Analysts and policymakers thus monitor movements of the major price indexes very carefully. As a result, the indexes are of considerable importance in determining both governmental and business strategies.

This three-part monograph examines the major price indexes.[1] The first part contains a discussion of the recent behavior of prices as measured by the indexes. It sets the stage for a discussion of the individual indexes by illustrating the severity of the recent inflation problem and emphasizing the importance of good measures of price changes. The second part explains the concept of a price index, reviews the criteria that a good price index must satisfy, and discusses conceptual and statistical problems associated with their design and construction. The final part describes the major price indexes in current use in the United States—the Consumer Price Index, the Producer Price Index, and the Implicit Price Deflator for the Gross National Product. The methodologies of these major indexes are then examined in the light of the criteria outlined in the second part. Finally, a short list of reference material is presented to aid the reader interested in pursuing more detailed research on price indexes.

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[1] This monograph first appeared as a three-part series in the Federal Reserve Bank of Richmond's *Monthly Review*, the September, October, and November 1970 issues.

Recent Price Behavior

Inflation, according to former Commissioner of Labor Statistics, Geoffrey Moore, is a rise in prices that is both general and widely diffused [18, p. 3]. The accompanying charts of the indexes indicate the pervasiveness of the price increases that have occurred in this country in recent years. They also show accelerating price rises in nearly all categories during the decade beginning in 1965—the year that, according to most observers, marks the beginning of one of the most serious bouts with inflation that this country has experienced since post-World-War II days.

The charts show annual figures for the indexes on a ratio scale, which permits visual comparisons of percentage rates of change. The average annual rates of change in the indexes are shown as straight lines on the ratio scale. These average rates are given for the five-year period, 1972 through 1977 and for the longer 1960-1977 time period. No attempt is made in this first part to comment upon the merits of the particular indexes under discussion. Rather, attention is focused upon the implications of the movements in the indexes.

The figures shown in the charts are the published annual averages of the indexes, and the average annual rates of growth are based upon those averages. In comparing price changes for a given year with those that occurred in the preceding year, however, it is often more meaningful to compare year-end to year-end changes, for the results of the two approaches could differ significantly during periods of rapidly accelerating or decelerating price changes. For example, according to the annual averages, the Consumer Price Index increased 11.0 percent in 1974, 9.1 percent in 1975, 5.8 percent in 1976, and 6.5 percent in 1977. Comparing year-end to year-end changes, however, the index

rose 8.8 percent in 1973, 12.2 percent in 1974, 7.0 percent in 1975, 4.8 percent in 1976, and 6.8 percent in 1977. As a measure of the amount of price increase that took place during a year, the year-end over year-end figures are superior, provided that one can be reasonably confident that the year-end figures are not distorted.

CONSUMER PRICES

Chart I shows values of the Consumer Price Index for all items and for the major categories—all commodities, food, and services. The chart shows clearly the acceleration in price increases during the 1960-1977 time period. Prices of all categories of consumer goods rose relatively modestly from 1960 to 1965 (1.3 percent per year), increased at a more rapid 4.2 percent annual rate during the 1965-1970 time period, and rose at an even higher 6.6 percent annual rate from 1970 to 1977.

As a result of these yearly increases, the all-item Consumer Price Index was 105 percent higher in 1977 than it was in 1960.[2] The thrust of the inflationary advance apparently peaked in 1974, when there was a 12.2 percent year-end to year-end increase in the price index. Measured on the same basis, the index increased at a 7.0 percent rate in 1975, a 4.8 percent rate in 1976, and a 6.8 percent rate in 1977.

In comparing the different indexes shown in Chart I, it becomes evident that the index of services prices advanced more rapidly than did the other indexes in the 1960-1971 period. After 1971, however, the commodity index—and particularly its food component—increased the most rapidly.

The Consumer Price Index is available in greater detail than that shown in the charts. A further breakdown would indicate that the rate of increase for the 1965-1977 period was more pronounced in prices of nondurable commodities than in durables. Prices of nondurable goods rose faster than durable goods prices even when food prices, which increased more than prices of other

[2] In the popular press one often sees statements that purport to convey the same meaning but that are phrased somewhat differently. Examples of such phraseology are ". . . prices of consumer items rose 105% from 1960 to 1977," or worse, ". . . the cost of living increased 105%. . . ." For reasons that will be discussed at length, the phrasing of both of these statements is incorrect.

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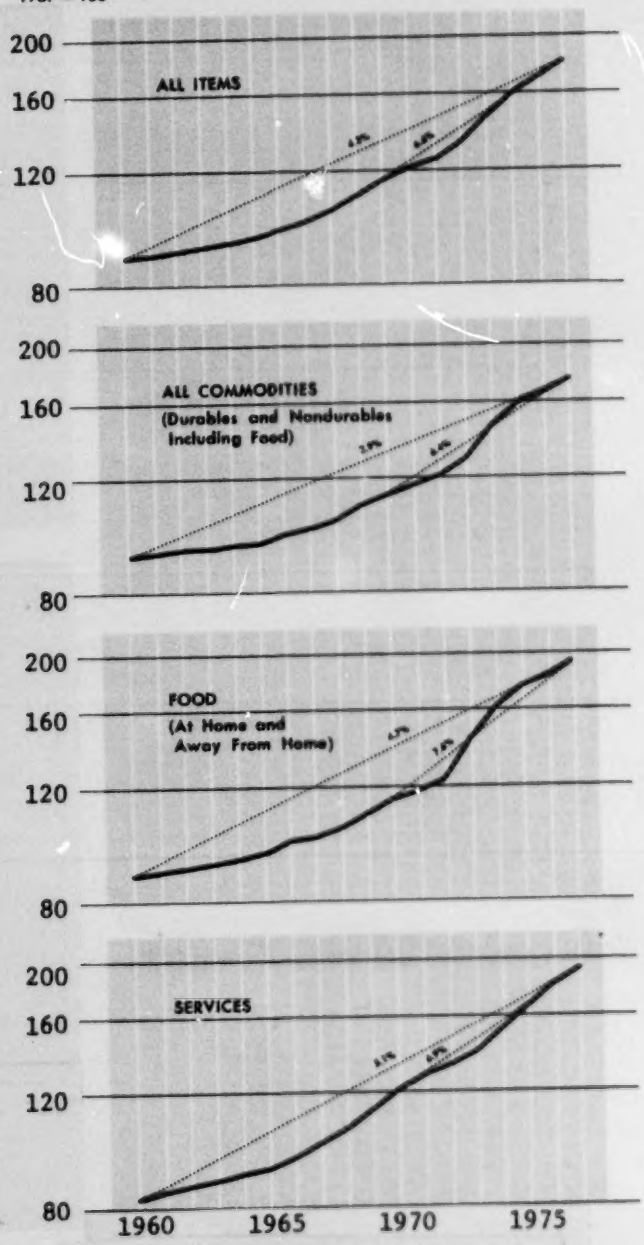
Chart I

INDEXES OF CONSUMER PRICES

1967 = 100



Source: U. S. Dept. of Labor

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nondurables, were excluded. In terms of average annual growth rates for the 1970-1977 period, food prices increased at a 7.6 percent rate, other nondurable goods at a 5.7 percent rate, and durables at a 5.6 percent rate. Prices of consumer services were boosted substantially by increases in costs of medical care, public transportation, and numerous costs associated with home ownership, such as mortgage interest, repair services, etc. A fully detailed discussion of movements in the items that make up the Consumer Price Index, however, is beyond the scope of this monograph.

A geographic breakdown of the Consumer Price Index is also available. Some details of the geographic sampling procedures are discussed in the final part, but it is useful here to compare recent price behavior in certain locations with the U. S. average. For example, since 1967, prices of all consumer items have risen more than the national average in Baltimore, Cincinnati, Houston, New York, Minneapolis-St. Paul, Philadelphia, and Washington. Prices in numerous other cities for which the index is published have risen less than the national average. There are 28 Standard Metropolitan Statistical Areas for which indexes are published as well as 57 other areas—some of which are SMSA's —from which samples are taken for use in deriving the national indexes. Indexes for SMSA's, however, cannot be used to compare costs of living among geographic areas, because they measure only *price changes,* as distinct from price levels. The recent movements of the indexes do indicate, however, that inflation has not exempted any area of the country. Indexes for all areas exhibit the kind of rapid price increase that has been typical of the U. S. at large for the past several years though there are significant differences among some of the cities in the rate of advance.

PRODUCER (WHOLESALE) PRICES

Chart IIa shows the Producer Price Index for finished goods, intermediate materials, and crude materials. Chart IIb shows the Index of 13 Industrial Materials Commodities, whose prices are considered among the more sensitive indicators of changes in economic conditions. Movements in the Producer Price Indexes often portend changes in prices of consumer goods, though the

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Chart IIa

INDEXES OF PRODUCER PRICES

1967 = 100

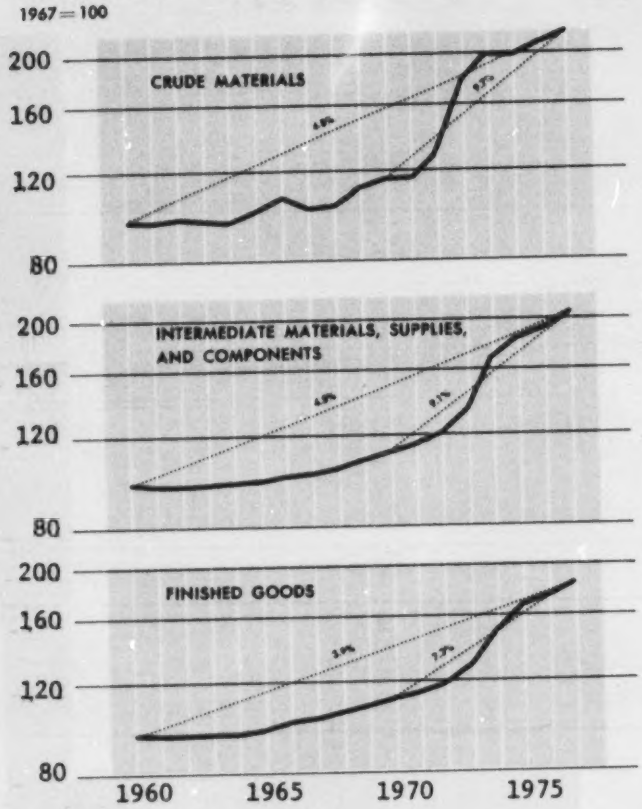
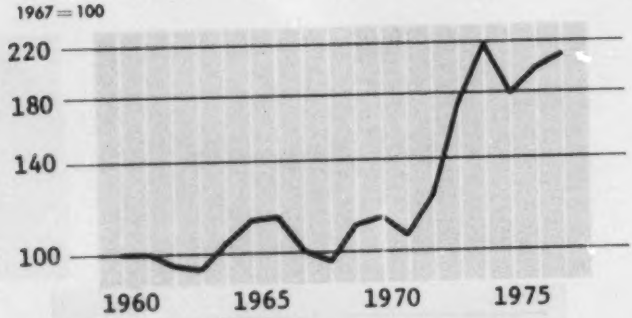


Chart IIb

INDEX OF INDUSTRIAL MATERIALS PRICES

1967 = 100



Source: U.S. Dept. of Labor

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indexes differ considerably in design and coverage from the Consumer Price Index.

Producer Price Indexes are published both by stage of processing and by commodity. The Bureau of Labor Statistics, however, places primary emphasis on the stage-of-processing indexes, because the All Commodities Index is subject to double counting. (See Nordhaus and Shoven [20, pp. 14-22] for a discussion of the measurement distortion that occurred in the All Commodities Index in 1973 as a result of multiple counting of price changes.) The stage-of-processing indexes, also, are the most useful in determining prospective changes in the consumer price level. The 2800 commodities covered by the indexes include not only finished goods, but also intermediate and crude materials. Changes in producer prices for finished goods translate rapidly into changes in consumer prices and therefore, are widely considered to be an important near-term indicator of movements in the Consumer Price Index. On the other hand, movements in prices of crude materials, which include such items as basic farm commodities, iron and steel scrap, iron ore, coal, etc., often indicate strategic shortages and surpluses that eventually will be of concern to the consumer.

Like consumer goods prices, producer prices were relatively stable during the first half of the 1960's but began to advance more rapidly in the latter half. In the 1970-1977 period, however, the All Commodity Index increased at a considerably faster (8.4 percent) rate than the Consumer Price Index's 6.6 percent average rate of advance. As is clear from the chart, the most rapid increases in these producer prices came in the 1972-1974 time period. Chart IIa indicates that the pattern of increase was similar for commodities in all stages of processing. Crude materials (which include farm products) showed the most erratic pattern, with extremely sharp increases in the 1972-1974 period.

The crude materials component of the Producer Price Index has historically tended to fluctuate widely. Such price variation has been particularly characteristic of farm products, where changes in the short-run supply and demand conditions affect prices significantly. These demand and supply fluctuations have been exacerbated in recent times by international factors such as shortages abroad and floating international exchange rates.

The industrial commodities component of the Producer Price

Index, after a period of stability, began to rise steadily in 1964, with the rate of advance accelerating markedly in the 1973-1975 period and decelerating somewhat in the 1975-1977 period. Some categories of the component, such as fuels, metals, lumber, and nonmetallic mineral products, display very rapid growth while other categories, such as textile products and apparel, furniture and appliances, leather products, rubber, transportation equipment, and pulp, paper and allied products, reveal only slow to moderate growth. Mixtures of growth patterns occur within categories, too. For example, the fast-growth woodpulp subcategory and the slow-growth building paper and board subcategory are both classified under the moderate-growth paper category. Thus, the analyst should be aware that the incidence of price increase is sometimes obscured by looking only at the aggregative indexes. In addition, and as will be discussed later in the monograph, the analyst should use some extra caution in interpreting the Producer Price Index numbers, because the indexes may not be as sensitive to changes in prices as they seem.

Initial inspection of the 13 sensitive industrial commodities in Chart IIb reveals a somewhat confused picture. This group consists of 13 raw industrial commodities for which there are daily spot market prices on organized exchanges. Prices of basic commodities included, therefore, quickly register changes in supply and demand conditions and are widely considered to be leading indicators of changes in the Producer and Consumer Price Indexes [3, n.l, p. 46].

The average annual growth trend in the Sensitive Commodity Index from 1960 through 1971 was positive, but Chart IIb shows that the pattern of increase, in exhibiting a more pronounced cyclical pattern, differed markedly from that of producer prices in general. The most dramatic change in the index occurred during the 1971-1974 time period when the index more than doubled. Perhaps better than any other statistic, this index illustrates the character of the worldwide inflationary boom experienced in 1972-1975. As firms attempted to beat inflation by carrying larger inventories and stock-piling basic materials whose prices were expected to rise, the demand for these commodities became even more intense and the increases in their prices accelerated. Fortunately, this sort of speculation subsided, and since its decline in 1975 the index has risen at a slower pace.

S1

GNP IMPLICIT PRICE DEFLATOR

Chart III shows the Implicit Price Deflator for Gross National Product. Each component of GNP, in as fine detail as possible, is deflated for a given year or quarter by the indexes which are appropriate for the particular component. Once deflated, the components are again aggregated to obtain GNP in constant dollars, and the implicit GNP Deflator is found by dividing current dollar GNP by constant dollar GNP. Thus, the Deflator is an implicit index derived in a roundabout manner.

Since the index depends upon previously determined indexes of consumer and wholesale prices, as well as several other indexes, it should be interpreted with care. For example, sub-components of the consumer spending component of GNP are deflated mainly by appropriate Consumer Price Indexes. The gross private domestic investment component of GNP is deflated by various Producer Price Indexes, except for construction, which is deflated by construction cost indexes prepared by the Bureau of the Census and others. Thus, the aggregate GNP Deflator reflects the behavior of several indexes. Also, its value for any given period depends upon the composition of GNP for that period, so changes in the index can, at least theoretically, measure changes in things other than prices. Further discussion of the technical qualities of the GNP Deflator is contained in the final part of this monograph.

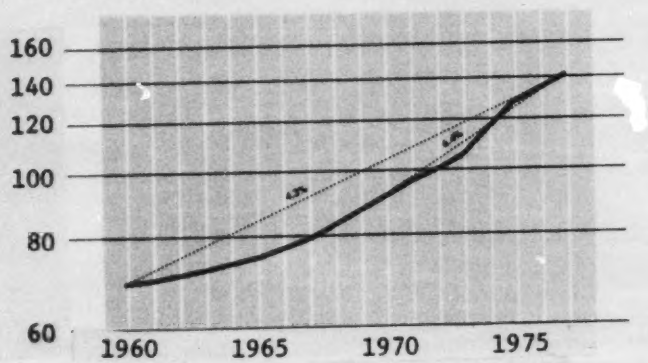
Chart III shows that the "price" of the Gross National Product, like prices reflected in the other indexes, advanced consistently over the long period, 1960 through 1977 at generally accelerating rates. The increase in the GNP Deflator, tapered off somewhat in the 1975-1977 period, however. Measured in year-end over year-end changes, the index increased 11.5 percent in 1974, but only 5.8 percent in 1977. This is consistent with the recent performance of consumer and producer prices.

A further breakdown reveals that since 1967 certain components have advanced more rapidly than the aggregate deflator, namely the nondurable goods component of consumer spending, the residential and nonresidential construction components of investment spending, and Federal, state and local government spending. In contrast to these rapidly advancing categories, producers' durable goods and the durable goods component of consumer spending advanced at a more moderate rate. All the com-

Chart III

IMPLICIT GNP DEFLATOR

1972 = 100



Source: U.S. Dept. of Labor

ponents, as well as the aggregate, however, exhibited a big jump in 1974; many doubled, and some even tripled, the annual increase for the previous year.

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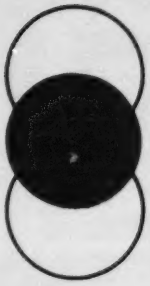

The Design and Construction of Price Indexes

An index in the simplest sense is a ratio of one quantity to another. It expresses a given quantity in terms of its value relative to a base quantity. Thus, a price index designed to measure price changes in an item over time is a ratio of one price to the price of the item in a different period of time. Several conceptual and statistical issues are involved, however, in developing the more complex price indexes that are designed to measure the movement of aggregate prices over time. These issues are raised in the discussion that follows.

As a hypothetical example of the price index concept, suppose that there were a consumer whose total budget consisted of five items and whose expenditures on the items were known for a period of four years. Three of the items were large in relation to his total budget. Two of these, automobiles and suits, were purchased infrequently; but rent was paid frequently. The remaining two items were small, but one, bread, was purchased frequently, and the other, movie tickets, infrequently. The five items taken together make up the consumer's "market basket"—a term commonly used to refer to the sample of items upon which an index is based. Usually, of course, the "market basket" reflects, as nearly as possible, actual consumer purchases. This simplified example, however, is sufficient to illustrate a number of the issues. Table I details the consumer's situation.

CONCEPTUAL PROBLEMS

The Base Period The selection of an appropriate base is fundamental to the development of index numbers. If a price index is to serve as a stable basis for comparison of price move-

ments over time, a period of time must be selected and held as the base long enough to generate a series of indexes for subsequent periods that will be useful in comparing those periods not only with the base but also with each other.

In devising an aggregate index for general-purpose use, the selection of the base period is necessarily somewhat arbitrary. Under ideal conditions, however, the base period chosen would be one in which sharp fluctuations in prices in underlying economic conditions would be minimal. Such "normal" periods are difficult to find, since prices of hundreds of items must be taken into account. If the index is of the special-purpose variety, however, the selection of an appropriate base is somewhat easier. For example, the earliest concern with index numbers involved an attempt to measure changes in the purchasing power of money (i.e., the reciprocal of the price index) resulting from the importation of silver into Europe after the discovery of America. This first price index, developed by Carli in 1764, covered a 250-year time span with the year 1500 as its base [19, p. 6].

Base periods of price indexes are occasionally updated for convenience. Also, as spending patterns change and as technological change occurs, particular selections of goods and services in the "market basket" become obsolete as standards for comparison. Items purchased in the current period either may not have been available or may have undergone substantial quality changes since the base period. A revision of the sample of items in the "market basket" is required to account for these changes, and a sample revision is often accompanied by a shift of the base period to one that better represents the revised sample of goods and services.

Although sometimes desirable, it is not necessary that both of the above changes be made at the same time. An updating of the "market basket" can be accomplished without shifting the base, if the revised selection of items is worked into the sample without distorting the continuity of the index. This type of adjustment is discussed later in connection with other statistical problems. A straightforward shift of the base period without changing the sample of goods and services is also possible and quite simple to accomplish. For example, if the index of 1970 prices for a particular sample of items on a 1960 base is 120.0 and the index on the

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same base was 105.0 in 1965, then 1970 prices can be expressed on a 1965 base as 114.3, or 120.0/105.0.[3] This kind of linkage, while frequently used, does nothing to improve the quality of the index. This procedure was used by the Bureau of Labor Statistics in 1971 to rebase its indexes of wholesale and consumer prices to 1967 from their former 1957-1959 base period. The revised number gave the same information as the original index and in no way allowed for changes in quality of goods and services or changes in spending patterns. Thus, the most crucial test of an index is whether its market basket continues to be representative. If it is, revisions of the base period may be convenient but not essential.

Simple Average of Relatives and Simple Aggregative Price Indexes The simplest form of price index is the ratio of one price to another for a specified commodity. This approach, however, has only a narrow range of applicability. For example, consider the consumer whose expenditures are shown in Table I. Assuming that the loaf of bread in the table is of the same size and quality in all four years, a simple index of the price of bread in year 2 is 110.0 (year 1 = 100). For years 3 and 4, the index is 125.0 and 115.0, respectively. As far as it goes, this index measures the changes in the price of bread accurately. If there were no change in quality of the other four items shown, similar price indexes could be constructed for them. But a serious problem arises, even in the absence of any quality changes, if a composite index of the consumer's "market basket" is desired.

Consider, for example, the change between the first and second years. The price index for bread, as previously stated, is 110.0; for automobiles, it is also 110.0; for rent, it is 106.3; for movie tickets, it is 133.3; and for suits, it is 111.8. A simple average of the individual indexes yields a composite index of 114.3 for the consumer's total budget in year 2, based upon year 1. The interpretation of this average is questionable, however, since it implicitly gives the most weight among the five items to

[3] It is common practice to express index numbers as ratios multiplied by 100 and rounded to one decimal place (e.g., the index 114.3 is the ratio 1.143). It is understood throughout this article that a ratio obtained by any formula is multiplied by 100 to obtain an index. For simplicity that step is not shown in the calculations or formulas.

Table 1

CONSUMER WITH A HYPOTHETICAL FIVE-ITEM "MARKET BASKET"

Prices and Quantities Purchased

Item	Years							
	1		2		3		4	
	p_1	q_1	p_2	q_2	p_3	q_3	p_4	q_4
Automobiles, each	$2,000.00	1	$2,200.00	1	$2,500.00	0	$2,500.00	1
Rent, per month	$ 80.00	12	$ 85.00	12	$ 100.00	12	$ 130.00	12
Bread, per loaf	$ .20	250	$ .22	275	$ .25	275	$ .23	300
Movie tickets, each	$ .75	10	$ 1.00	6	$ 1.25	10	$ 1.35	10
Suits, each	$ 85.00	4	$ 95.00	4	$ 115.00	3	$ 135.00	1
Total Expenditures	$3,357.50		$3,666.50		$1,626.25		$4,277.50	

Note: Subscripts represent years, and p and q represent prices and quantities, respectively.

the one whose price rises by the highest percentage. In the example, that item is movie tickets, one which is likely to be of relatively little consequence to the consumer.

The index formula used in the above illustration is known as a simple average of relatives, or

$$I_{1\,2}=\left[\Sigma(p_2/p_1)\right]/n,$$

where $I_{1\,2}$ represents the value of the index for year 2 based upon year 1; p_1 and p_2 represent prices of individual items in years 1 and 2, respectively; Σ is the standard symbol for summation; and n is the number of items comprising the index [17, Ch. 13].

Other means of averaging the price relatives (or ratios) could easily be used. For example, a median of relatives (110.0 in this case) reduces the upward bias resulting from the increase in movie ticket prices. Other measures employed to reduce upward bias resulting from a sharp rise in one item or component are geometric and harmonic averages. A comparison of all these procedures for the hypothetical example is shown in Table II and selected indexes are graphed in Chart IV.

For comparison, another naive type of index number construction is the simple aggregative type. For the consumer under discussion, the total of the prices of the items in the base period is \$2,165.95. In year 2, the total of these prices is \$2,381.22. A simple aggregative index number for year 2 is

$$I_{1\,2}=\Sigma p_2/\Sigma p_1=109.9.$$

This procedure implicitly gives the highest weight to the item that has the largest absolute price change. In year 2 that item is automobiles, which increased \$200. Simple aggregative indexes are given for the four years in Table II and in Chart IV. The chart illustrates that this index has practically no increase in the fourth year when auto prices do not rise, even though the other indexes shown continue to climb.

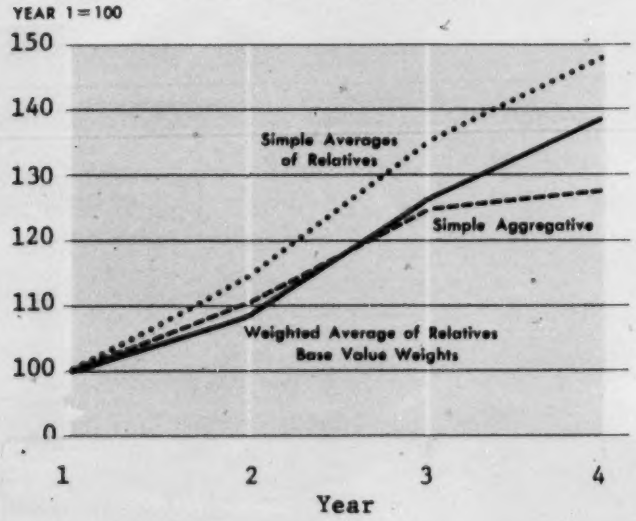
Both of these simple index methods illustrate the difficulties that arise in developing aggregate price indexes. In one case, bias arose because of large relative price changes (the movie ticket example); in another, because of large absolute price changes that were actually small relative to the price of the item (the

automobile example). In this illustration, neither of these aggregation procedures gives a valid indication of the true impact of price changes on the consumer. By contrast, the procedures outlined below are clearly preferable and explicitly weight the items according to their relative importance in the consumer's total budget.

Choice of Weights Should the weights needed to correct the bias resulting from the simple index methods be derived from the quantities purchased? There is certainly no doubt that the quantities purchased provide information on the relative importance of the items to the consumers, but the quantities that consumers buy are also affected by other factors. And, unfortunately for those who develop price indexes, consumers change the quantities of items that they buy in response to price changes. Business purchasers presumably do the same, to the extent that substitution of items is possible. Thus, although most observers agree that quantities purchased should be used as weights, there

Chart IV

COMPARISON OF SELECTED SIMPLE AND WEIGHTED PRICE INDEXES FOR HYPOTHETICAL CONSUMER



Source: Table I.

Table II

SELECTED PRICE INDEXES FOR HYPOTHETICAL CONSUMER EXPENDITURES

(Prices and Quantities from Table I)

	Simple Indexes				
Year	Simple Average of Relatives Index	Median of Relatives Index	Geometric Average of Relatives Index	Harmonic Average of Relatives Index	Simple Aggregative Index
1	100.0	100.0	100.0	100.0	100.0
2	114.3	110.0	113.9	113.5	109.9
3	135.4	125.0	134.5	133.7	125.4
4	148.3	158.8	146.2	144.1	127.7

	Weighted and Weighted Chained Indexes						
Year	Weighted Aggregative Index Laspeyres Type	Weighted Aggregative Index Paasche Type	Weighted Average of Relatives Index Base Value Weights	Weighted Average of Relatives Index Current Value Weights	Fisher's "Ideal" Index	Edgeworth's Index	Weighted Aggregative Laspeyres Type Index Chained
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	109.2	109.1	109.2	109.2	109.1	109.1	109.2
3	126.1	127.3	126.1	127.5	126.7	126.5	126.1
4	139.1	137.4	139.1	139.8	138.2	138.3	158.3

has been some divergence of opinion regarding exactly what quantities should be used.

For example, in Table I, the consumer's total budget or expenditure in year 1 was \$3,357.50 (i.e., Σp_1q_1). His total expenditure in year 2 was \$3,666.50 (i.e., Σp_2q_2). A ratio of these expenditures would not measure price changes *per se* under most circumstances, since quantities change as well as prices. The resulting ratio is not a pure index of price changes but simply a ratio of budgets or total expenditures. The consumer's standard of living may have changed at the same time as a result of changes in his income, changes in the quality of items that he purchased, and for numerous other reasons. The type of question that a price index is probably most often expected to answer is how much it would cost the consumer in the current period to purchase exactly the same mix of items ("market basket") that he purchased in the base period. Price indexes, therefore, are usually constructed by choosing quantities purchased in the base period as weights and holding these weights constant in computing the index for subsequent periods. If such weights are used, however, periodic updating of the "market basket" is a necessity if the index is to continue to be representative of actual consumer purchases. As will be shown in subsequent discussion, not all indexes are designed to answer the specific question posed above, so there is some variance in the methods used to construct indexes.

The type of index just described is of both the fixed-weight and fixed-base variety. Another type of index designed to answer a different sort of question uses current period weights. Quantities purchased in the current period are used to weight both current and base period prices. Thus, this type of index tells how much it costs the consumer to obtain a given selection of items in relation to how much it *would have* cost him to obtain the same selection in the base period. This is important information of course, but period-to-period comparisons are somewhat more difficult than with the fixed-weight, fixed-base type, described earlier.

Weighted Aggregative Indexes--The Laspeyres Type The price index that one encounters most often is the fixed-weight and fixed-base type. It was developed by Etienne Laspeyres in 1864. For the consumer expenditures shown in Table I, this index results in a value for year 2 of

$$I_{1\,2}=\Sigma p_2q_1/\Sigma p_1q_1=109.2.$$

The values of this index for the four years are shown in Table II. The index is of the weighted aggregative type since it is the ratio of two expenditures—the numerator representing the items purchased in the base period at current prices, and the denominator being the actual base period expenditure [7, p. 59].

A strict interpretation of the value, 109.2, given above for this consumer is that it would cost him 9.2 percent more to purchase the identical "market basket" in year 2—if he desires to purchase it—than it cost him in the base year. Similarly, the same selections would cost him 39.1 percent more in the fourth year than in the base year, as shown in Table II. This index construction reduces the aggregation biases in the simple indexes mentioned earlier.

Weighted Aggregative Indexes--The Paasche Type A weighted index of this type uses current period quantities as weights. It was developed by H. Paasche in 1874. For the consumer in Table I, for year 2, the index number is

$$I_{1\,2}=\Sigma p_2q_2/\Sigma p_1q_2=109.1.$$

Other values are shown in Table II. This index, like the Laspeyres, is a ratio of weighted aggregates. But it relates an actual current period expenditure in the numerator to a hypothetical base period expenditure in the denominator [7, p. 59].

The correct interpretation of the Paasche number is that it costs 9.1 percent more to purchase the current period "market basket" than that "market basket" would have cost in the base period. This index also reduces the aggregation biases present in the simple indexes. In this illustration, a lack of sufficient variation in the quantities purchased between years 1 and 2 results in the Paasche and Laspeyres index numbers being very close together. But if, for example, the consumer had reacted to the increase in automobile prices by not buying one in the second year, the Paasche index number would have been 107.9. The Laspeyres index for year 2, however, would not have been affected, since only base period quantities are relevant. Thus, the Laspeyres number would have remained 109.2.

An important difference in the kinds of interpretations that may be made of these indexes should be noted. Table II shows the Laspeyres index to be 109.2 in year 2 and 126.1 in year 3. It may be concluded, therefore, that the cost of the "market basket" increased 15.5 percent between years 2 and 3 (i.e., $(126.1 - 109.2)/109.2 = .155$). The "market basket" that the consumer purchased in the base period would cost him 15.5 percent more in year 3 than it would have in year 2. A similar interpretation of the change in the Paasche index between these two years, however, would be incorrect. Each successive Paasche index number compares the current period "market basket" directly to the base year. The selection actually purchased in year 3 cost the consumer 27.3 percent more than it would have cost in the base year, and the selection actually purchased in year 2 cost 9.1 percent more than it would have cost in the base year. Since the particular selection of commodities being priced changes between years 2 and 3, a direct comparison of the index numbers to measure price changes between the two years would be inappropriate. A similar difficulty in the interpretation of the GNP Deflator will be discussed in the final part of this monograph.

Laspeyres and Paasche Compared Both of the weighted aggregative indexes are superior to any of the previously discussed simple indexes. They reduce the likelihood that the indexes will be biased because of either large relative changes in prices of items or large absolute changes. They are also free of the problems associated with the units in which the price is quoted.

There is a considerable body of literature on the Laspeyres and Paasche indexes, and there has been considerable discussion on the pros and cons of each. While it is beyond the scope of this article to review all the literature, some of the discussion is particularly pertinent, since the Laspeyres index is in essence the one used by the Bureau of Labor Statistics in constructing both the Consumer Price Index and the Producer Price Index.

If a choice must be made between the Laspeyres and Paasche index numbers, it would seem that on logical grounds the Laspeyres index provides the best answer to the question most often asked of index numbers, namely, how much did the cost of the base year "market basket" change? There are certain other

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factors, however, that affect the choice between the two—ignoring for the moment any sampling problems that may be involved. It has been noted that the Laspeyres formula has a tendency to overstate price increases, while the Paasche formula tends to understate price increases. The hypothetical current expenditure, Σp_2q_1, used as the numerator of the Laspeyres index, is probably not an accurate representation of the actual choice of goods that the consumer would make in the second year. The sum, Σp_2q_1, would of course be sufficient to allow the consumer to purchase the base period "market basket," but in a period of generally rising prices, it could be larger than the actual expenditure, Σp_2q_2. Rational consumers adjust their purchases in response to changes in relative prices, substituting purchases of other items for those in the original "market basket." Thus, the Laspeyres index assumes that consumer demand is completely price inelastic, and since this assumption is invalid, the effects of the price changes on the consumer are somewhat overstated.

The Paasche index is subject to a similar criticism. It uses a hypothetical base expenditure, Σp_1q_2, as its denominator for the second year. During a period of generally rising prices this sum would be smaller than the numerator, Σp_2q_2, which is the consumer's actual expenditure in the current period. The criticism here is that a lower sum of money given to the consumer in the base period probably would have induced him to purchase a different set of commodities than the "market basket" that he chose in year 2 when he had more money available. To the extent that this is true, the effects of higher prices on the consumer are likely to be understated by the Paasche formula.

These criticisms do not necessarily imply that the two indexes are biased in every instance, nor do they imply that the Laspeyres number is always greater than the Paasche. Actual consumer purchases respond to a variety of economic factors. Particular economic circumstances can even move the indexes in opposite directions from those mentioned above. For example, if consumers were to shift purchases toward goods or services that were advancing rapidly in price, the use of base period quantity weights in the Laspeyres index would cause it to underestimate actual price changes. If the statistician were able to measure the bias imparted to the index, it would be a simple matter to correct the numbers. Unfortunately, the bias cannot be quantified be-

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cause what the consumer might have done cannot be observed experimentally.

These theoretical criticisms illustrate why it is frequently argued that neither index can provide a valid measure of the effects of changes in the cost of living. A cost of living index should measure the change in the cost of obtaining a given standard of living from one period to another. Living standards, however, are subjective, and the consumer does in fact shift his purchases in response to changing prices in order to minimize his losses and maximize his gains. An index that cannot take such adjustments into consideration, therefore, cannot be a reliable index of the cost of living.[4]

Fisher's "Ideal" and Edgeworth's Indexes

Concern about biases in the Laspeyres and Paasche indexes led Irving Fisher to develop, in 1922, a number of tests for estimating the magnitude of error in various index number formulas [7, Ch. 11]. As a result of these efforts, Fisher developed an "Ideal" index that recognized the opposing biases in the Laspeyres and Paasche approaches. His "Ideal" index is a geometric average of the Laspeyres and Paasche indexes. A geometric average is the n-th root of the product of n numbers (i.e., the geometric average of two index numbers is the square root of their product), and it always yields a value that is somewhat smaller than a simple arithmetic average. Thus, the "Ideal" index is closer to the lesser of the Laspeyres or Paasche results. The values of this index are given in Table II for our hypothetical consumer.

Because of the computational difficulties involved in the practical application of the "Ideal" index to large samples of price data, Edgeworth, a contemporary of Fisher, developed a close approximation that makes use of quantity data for both the base and current periods. Edgeworth's index is defined as

$$I_{1\,2}=\Sigma(q_1+q_2)p_2/\Sigma(q_1+q_2)p_1,$$

where year 1 is the base. For comparison, values of this index are also shown in Table II [17, Ch. 13].

[4] The problems of constructing cost of living indexes have resulted in extensive research. For detailed discussion, see Ulmer [27], Frisch [8], and Konus [16].

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Weighted Average of Relatives Indexes The weighted average of relatives index number differs only in formula construction from those already covered—a fact that has important practical value in the calculation of the index. It was noted in the discussion of weighted aggregative indexes that prices are weighted by quantities purchased. By comparison, the weighted average of relatives index weights price relatives (ratios of prices) by total expenditures (value of purchases). A choice must be made again between base period or current period expenditures as the weights. Consider first this type of index using base period expenditures as weights (i.e., base value weights). The index for year 2, where year 1 is the base, is

$$I_{1\,2}=\Sigma\left[\frac{p_2}{p_1}\cdot p_1q_1\right]\Big/\Sigma p_1q_1.$$

The price relative is the simple ratio of prices, p_2/p_1. The base value weight is the total expenditure in the base period, p_1q_1, for an individual commodity. The weight is multiplied by the price ratio, and these quantities are summed for all items in the "market basket." The denominator is the base period expenditure on all items in the "market basket." It can be seen above that p_1's in the numerator cancel, so that the formula reduces algebraically and is identical to the Laspeyres-type weighted aggregative index. This is not the important distinction, however, because the formula is used as it is shown rather than in its reduced form. As a practical matter, quantities purchased are often unavailable, making the direct application of the Laspeyres formula difficult. But prices and actual expenditures on individual items are more readily available, with the result that the weighted average of relatives index can be calculated more easily than any of the other weighted indexes discussed. With minor modification, this index is the one used by the Bureau of Labor Statistics in deriving both the Consumer Price Index and the Producer Price Index.

A weighted average of relatives index can also be constructed with current value weights if current period expenditures, p_2q_2, are used in the numerator and the total of current period expenditures for the current "market basket," Σp_2q_2, for the denominator. This index does *not* reduce to the Paasche weighted aggre-

gative index, but it is easier to apply than the Paasche index for the reasons given above. This construction is known as the Palgrave index formula. It has received little recent attention by students of index numbers, however, and is discussed here only for completeness. For comparison, the values of the two weighted average of relatives indexes are shown in Table II, and the index with base value weights is also plotted on Chart IV.

Chain Indexes All of the indexes discussed thus far have been fixed-base indexes. That is, it has been assumed that the base period upon which the index is computed is constant. Chain indexes involve constantly shifting base periods.

The use of a fixed-base index implicitly assumes that nothing of importance changes except price over the span of time between the base period and the current period. That assumption may not be valid if economic conditions are changing rapidly and technological progress that affects the quality of items included in the index is occurring. At best it means that frequent updating of the weights and frequent revisions of the sample of commodities in the "market basket" are essential. A fixed-base index with base period weights is particularly suspect in this connection, and this is the concept used in constructing most major price indexes in use today. A fixed-base index using current period weights such as the Paasche type is perhaps less subject to criticism on this score, but it is questionable whether such an index gives the most useful measure in the first place. Even so, base period prices are still the basis of comparison. Given that an index of the Laspeyres type is the preferred concept, the problem of how to make it consistently valid over any reasonably long period of time becomes significant.

A Laspeyres-type index number for any given year ignores the effects of price changes that may have occurred in the years since the base year. As noted earlier, however, intervening price changes can affect spending patterns significantly. Chain indexes provide expedient means for resolving this difficulty.

The chain procedure entails updating the base each time, so that the index for any given period uses the previous period as a base. The indexes are then linked together in a multiplicative fashion. Using the Laspeyres formula as an example,

$$I_{1\,2}=\Sigma p_2q_1/\Sigma p_1q_1,$$
$$I_{2\,3}=\Sigma p_3q_2/\Sigma p_2q_2, \text{ and}$$
$$I_{1\,3}=I_{1\,2}\cdot I_{2\,3}, \text{ etc.}$$

The chain index for year 3 uses the quantities purchased in year 2 as weights. The index for any given year can be expressed with any earlier year as the base by multiplying the indexes starting with that earlier year.

Table II shows values of the chained Laspeyres index, for the hypothetical consumer, using year 1 as the base. Table III gives all combinations of the chained Laspeyres index for the four years.

Table III

CHAINED LASPEYRES INDEX FOR HYPOTHETICAL CONSUMER EXPENDITURES

(Prices and Quantities from Table I)

$I_{1\,2}=109.2$	$I_{1\,3}=126.1$	$I_{1\,4}=158.3$
	$I_{2\,3}=115.5$	$I_{2\,4}=145.1$
		$I_{3\,4}=125.5$

Price increases that occurred between years 3 and 4, as measured by the Laspeyres formula, are larger than in any other two successive years in this illustration. The effect of the chaining procedure is evident in the value of $I_{1\,4}$, which shows the compounded result of the price rises of each successive year. Any consistent biases present in the index formula, however, will lead to cumulative error by chaining. The chained Laspeyres index indicates price increases to be 13.8 percent greater between years 1 and 4 than the fixed-base Laspeyres index (i.e., 158.3 vs. 139.1). While the divergence between the two indexes is large in the fourth year, the example does not imply that the chain method is invalid as such.

The use of the chain method has been recommended by some observers [19, pp. 70-78] as a means of keeping the index close to the market situation. It allows for the shifting of purchases in response to changes in prices more readily than does the fixed-base type. Thus, in a period of rapidly changing prices, such as in recent years, the chain method has some attraction, particularly

as a supplement to a fixed-base index. The difficulties involved in the interpretation of chain indexes, however, as well as their tendency to magnify successions of sharp price changes, pose serious problems. The chain index alone, therefore, is not generally considered to be a satisfactory solution to the problem.

STATISTICAL PROBLEMS

A number of statistical problems still remain even after an appropriate index number concept has been selected. This is particularly true of a general-purpose index in which the coverage of items is broad and where the index is used to represent the behavior of prices in general. These are features of the published indexes of producer and consumer prices. While there are stated limitations to the interpretations that may be made from these indexes, their usage has evolved in such a way that they are regarded as broad indicators of price changes.

The remainder of this section will only list and explain the nature of the statistical problems involved in the construction of the aggregate price indexes. This discussion is not a review of procedures in actual use by those government agencies or others who produce the indexes but is a more general explanation of the types of problems to be encountered by anyone involved in the construction of price indexes. Such problems are subsequently related to the procedures employed in developing the commonly used indexes of producer and consumer prices in the final part of the monograph.

Sampling of Items It is not feasible to derive a price index for consumers that includes all of the goods and services that they buy. Nor is it possible to develop an index of producer prices that includes all manufactured industrial items, all raw materials, and all farm products. Indexes intended for broad usage, therefore, rely on samples of items that are thought to be representative. Thus, the design of the sample critically affects the quality of the index. Just as there are important differences in spending patterns among urban and rural families, central-city and suburban families, and northern and southern families, there are important differences among individual families within each of these groups. For these reasons no single index can be applica-

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ble to all consumers. However, the new Consumer Price Index for all urban consumers covers the expenditures of approximately 80 percent of the population.

Sampling Over Time Once the coverage of the index as to groups of consumers or industries is defined and the selection of items in the "market basket" is specified, the question remains of how frequently the prices of the items included should be observed. It must be decided whether the index is to be published monthly, quarterly, annually, or by some other period. Under theoretically ideal circumstances, a continuous observation of prices would be desired. For obvious reasons, the cost of such a procedure would exceed the practical benefit. A satisfactory compromise on the problem can be reached if periodic samples of prices are used and if acceptable means of estimating interim prices can be derived for those periods between benchmark samples. For instance, if it is desired that a price index be published monthly and samples of prices are obtained every three months, previous experience with the "market basket" may provide sufficient information to allow estimation of prices, and therefore of the index, for the intervening months. Short-term movements in an index obtained on this basis are, of course, subject to error, particularly as underlying economic circumstances change.

Sampling Over Geographic Areas The commonly used aggregate price indexes are designed to be representative of the nation as a whole. Whether the index is of a special-purpose or general-purpose nature, however, its applicability is not necessarily the same in all parts of the nation. Just as general economic conditions vary widely among regions, price changes may vary widely by area. This variability is particularly applicable to indexes of consumer prices, which include numerous services and highly processed goods. Items that are essentially the same everywhere, for which highly organized national markets exist, and for which there is little variation in costs of production and delivery, are less subject to this problem (e.g., some of the items included in the index of industrial materials prices).

If a price index (e.g., of consumer items) is to be generally applicable over a wide geographic area, it is necessary to devise a

means of sampling among different places as well as a method of aggregating the data. Some indexes, such as the Consumer Price Index, are calculated by averaging indexes from narrower regions. Although it is clearly not practical to construct price indexes for every city or area in the nation, it is possible to vary the sample cities on a probability sampling basis to evaluate the error involved in the estimate of the national figure.

Quality Changes and Changes in Tastes The most difficult problems in price index construction relate to how often the "market basket" should be adjusted to account for (1) technological change, which affects the quality of goods and services purchased, and (2) changes in tastes and preferences of buyers. These problems, like the geographic area problem, are more serious in an index that measures prices of finished goods than in one that measures prices of basic commodities.

It is obvious that a television set purchased in 1977 is quite different from one purchased in 1957. It is a higher quality, more sophisticated piece of equipment. The same is true of many (although clearly, not all) consumer goods and services as well as equipment used by industry. The prices of many of these items have risen in recent years. Part of the price increase, however, results from the quality improvement and should somehow be eliminated in measuring the price change associated with the original "market basket." Without actually renewing the "market basket," the only generally satisfactory solution to this problem is to adjust out that portion of the price change attributable to the quality change. This procedure prevents disruption of the continuity of the index that would result from an abrupt substitution of the new or improved item in the "market basket." As a pratical matter, the rapidity of technological progress has made quality change a major problem in constructing indexes of consumer and industrial prices.

Changes in consumer tastes present the same kind of problem. As such things as garters, bed warmers, and washtubs have declined in the preference scales of consumers, the "market basket" has required updating to include entirely new products, such as panty hose, electric blankets, and automatic washers. The same situation is true of industrial items such as textile goods, where synthetic fibers have been substituted for natural fibers

because of cost advantages as seen by garment producers and consumer preferences. This problem, coupled with that of quality changes, necessitates continuous review of the "market basket."

Transactions Prices vs. List Prices Theoretically, all price indexes require prices used in calculating the index to be the actual prices at which transactions are made. Often, however, quoted prices do not change while significant changes occur in prices actually paid. Experience has shown this to be a problem, particularly in the measurement of industrial prices. A number of the industrial prices used in the Producer Price Index, for example, are seller's list prices, which may bear little resemblance to the prices actually paid. The Bureau of Labor Statistics is aware of this difficulty and uses list prices only when transactions prices are unavailable. Nevertheless, to the extent that list prices continue to be used, industrial prices may be overstated by failing to take account of discounts, special offers, and price shading. Thus, the Producer Price Index may not always accurately represent the effect of changing economic conditions. (It should be noted, however, that the index is considerably better in this respect than it once was. See Stigler and Kindahl [24]). The Consumer Price Index has not been subject to the same criticism, since price observers function like buyers and obtain prices that they know in most instances represent the prices at which the goods and services can be purchased.

Sampling Error in Indexes Even if all statistical problems are satisfactorily dealt with in the construction of price indexes, some error remains. This kind of error is a phenomenon of sampling, and it occurs even under the best of circumstances. An important feature of sampling error, however, is that its magnitude can be estimated, and it generally decreases as the sample size increases. This feature makes it possible to estimate with some degree of confidence (i.e., at some level of probability) how far the calculated value of the index can be expected to diverge from its correct value. Estimates of sampling error are frequently published along with the major indexes. It can be a mistake, however, to interpret estimates of sampling error too literally because sampling design considerations and data problems render all major indexes in current use less than perfect on other grounds.

Review of the Major Price Indexes

The Consumer Price Index
CHARACTERISTICS AND RECENT REVISIONS

The Consumer Price Index perhaps has more effect on day-to-day business decisions throughout the country than does any other economic statistic. It is used almost exclusively in cost-of-living clauses of labor contracts and in the great majority of other contracts with indexation clauses. The Bureau of Labor Statistics, in turn, expends a great deal of time and effort gathering the extraordinarily detailed data necessary for the construction of the index. The index was revised in early 1978, for example, and that revision was the result of eight years of research, costing approximately $50 million. The ordinary month-to-month costs of publishing the index are not inconsequential either, because myriads of items must be priced at thousands of retail outlets throughout the country. Few observers complain about the expenditure, however, because the U. S. Consumer Price Index has established itself as one of the most useful statistical series published anywhere in the world.

The 1978 revision was the first major revision of the index since 1964. A "major" revision, in the case of the Consumer Price Index, usually indicates changes in the "market basket" of goods and services to be priced. In the case of the 1978 revision, the "market basket" was indeed updated, but the revision included a number of other major changes as well. The most publicized change was the publication of an entirely new index.

The Consumer Price Index, before 1978, was designed to reflect expenditure patterns for urban wage earners and clerical workers. Since the revision, the BLS has published another Consumer Price Index as a companion to the old that is designed to

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reflect expenditure patterns for all urban consumers. The new index is thus broader than the old, covering the expenditures of approximately 80 percent of the total noninstitutional population, rather than the 45 percent covered by the old index.

In addition to broadening the coverage, the index has been updated and substantial changes have been made. In order to reflect the prices of goods and services purchased by all urban consumers, rather than just urban wage earners and clerical workers, the new Consumer Price Index not only has revised weights assigned to the components of the market basket, but it also includes different items and items priced at different kinds of retail outlets.

The form of the index, which is a slightly modified Laspeyres-type weighted aggregative index, was not changed by the 1978 revision. This type of index, as shown in the preceding part, is equivalent to a weighted average of relatives index with base value weights.

STATISTICAL AND SAMPLING TECHNIQUES. The "market baskets" for the current Consumer Price Indexes are based upon a Consumer Expenditure Survey conducted during the 1972-1973 period. The Survey covered approximately 40,000 families divided into two samples, and it was the most comprehensive expenditure survey ever undertaken. One sample was designed to gather data on major expenditures. It was administered by the Bureau of the Census, who interviewed 20,000 families quarterly over a two-year period. The other sample was designed to develop a "market basket" of smaller, more personal and less memorable purchases of goods and services. The data from this sample were taken from expenditure diaries that the families were asked to keep over a two-week period. Table IV compares the relative weights used for the "market basket" of the Consumer Price Index over the years to the weights derived from the 1972-1973 Consumer Expenditure Survey.

Incidentally, relative weights of the items in the "market basket" change between surveys. It can be seen from the table that the weighting structure in December 1977 is different from that of 1972-1973 even though both are based on the 1972-1973 survey of consumer expenditures. These differences reflect changes in *relative prices* of the various items since the revision, not changes

Table IV

RELATIVE WEIGHTS OF MAJOR CONSUMER PRICE INDEX COMPONENTS

Major Group	Wage Earners and Clerical Workers					All Urban Consumers	All Urban Consumers
	1935-39[1]	1952[2]	1963[3]	1972-73[4]	Dec. 1977[5]	1972-73[4]	Dec. 1977[5]
Food and alcoholic beverages	35.4	32.2	25.2	20.4	20.5	18.8	18.8
Housing	33.7	33.5	34.9	39.8	40.7	42.9	43.9
Apparel	11.0	9.4	10.6	7.0	5.8	7.0	5.8
Transportation	8.1	11.3	14.0	19.8	20.2	17.7	18.0
Medical Care	4.1	4.8	5.7	4.2	4.5	4.6	5.0
Entertainment	2.8	4.0	3.9	4.3	3.9	4.5	4.1
Personal Care	2.5	2.1	2.8	1.8	1.8	1.7	1.8
Other goods and services	2.4	2.7	2.9	2.7	2.6	2.8	2.6

[1] Relative importance for the survey period 1934-36 (updated for price change).
[2] Relative importance for the survey period 1947-49 (updated for price change).
[3] Relative importance for the survey period 1960-61 (updated for price change).
[4] Relative importance for the survey period 1972-73.
[5] Relative importance for the survey period 1972-73 (updated for price change).

in the "market basket" as such. As a hypothetical example, suppose that a consumer was spending a total of $100 per week in 1972 and allocating $25 (or 25 percent) to food and $10 (or 10 percent) to apparel. Suppose that the same consumer in 1977 was spending a total of $200 per week. If the 1972 expenditure weights were used, $50 would be allocated to food items and $20 to apparel items. But if food prices had increased 150 percent during the interim and apparel prices only 50 percent, the consumer spending $50 on food and $20 on apparel would be purchasing relatively fewer food items and more apparel items than he purchased in 1972. Thus, in order to keep the consumer's "market basket" in constant proportions, the changes in relative prices are adjusted out by changing the expenditure weights. As Table IV shows, food prices actually did increase relative to other prices between the 1972-1973 survey and December 1977, whereas apparel prices did not increase as rapidly as other prices.

The Consumer Price Indexes are currently based upon a point-of-purchase survey conducted in 1974. This survey of approximately 23,000 families was designed to find out where various population groups purchased their goods and services. It provides the guidelines for the month-to-month sampling conducted by the Bureau of Labor Statistics.

Since early 1978, prices have been observed in 85 areas rather than only in 56 as was the case in the preparation of the old CPI. Separate indexes are now computed for 28 cities rather than 24, and, for the first time, indexes for four regions stratified by five population size classes are published. The city and regional indexes provide measures of price *changes* for particular areas, but they cannot be used to compare living costs among the various places. The reason is simple. Although it is possible to measure the percentage *increase* in the index for one city or area relative to the *increase* in the index for another, the price levels in the two areas may have been quite different to begin with.

Actually, as mentioned earlier, the Consumer Price Index is not even a good measure of the *increase* in the cost of living, whether for particular areas or for the nation as a whole. A good cost-of-living index should allow consumers to shop around for substitutes when prices of one (or a group) of items rise more than prices of others. Since the Consumer Price Index does not wholly adjust for these substitution effects, the CPI tends to overstate the

increase in the cost of living in periods of rising prices. Changes in social security and income taxes can also cause the Consumer Price Index to misstate the change in the actual cost of living.

The 1978 revisions also introduced an improved method of item selection. The method, called "store specific pricing" is described in detail by Julius Shiskin [23]. In essence, the technique allows the pricing agent more leeway in selecting the items to be priced at a particular store. Prior to 1978, agents were limited to a list of 400 specific items. This limitation caused difficulties because a particular retail outlet might not stock the particular item that was to be priced. Store-specific pricing allows, within limits determined by probability calculations, agents to pick the items to be priced at a particular outlet from more general categories. They will then continue to price that specific item chosen periodically.

The Consumer Price Indexes, although published monthly, do not, strictly speaking, reflect month-to-month changes in prices. Some items are observed frequently (monthly) in every location; some are taken less frequently (bimonthly) in every location; some are observed frequently in selected locations only; and some are observed less frequently in selected locations only. Food items are among the most frequently sampled, and monthly sampling is the general rule in the five largest metropolitan areas. Even after the 1978 revisions only 53 percent of the items are priced every month, compared to 48 percent earlier.

In addition to these changes the BLS introduced the procedure of replicated (repeated) sampling in 1964 in an effort to provide better estimates of sampling error. Estimates of the standard errors of changes in major components of the Consumer Price Index have been published monthly by the BLS since January 1967. Research by Wilkerson [30] concluded that the estimates are reasonable approximations of the sampling error in the index. It further showed that changes in the published index—either monthly, quarterly, or for longer periods—greater than 0.2 percent are significant changes at the .05 probability level.[5]

Actually, monthly or quarterly changes of 0.1 percent or more are statistically significant, but since the published index numbers are rounded, a 0.1 percent change in the published data

[5] For detailed discussion of the sampling error estimates and the replicated sampling procedure, see [29].

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could come about as a result of a much smaller change in the rounded data. A 0.2 percent change for a one-month period, however, is almost always significant.

For example, if the value of the index were 100.0 a monthly change in the index to 100.1 or to 99.9 might not be of importance. Smaller changes have a high likelihood of resulting from random fluctuations in the sample of data rather than reflecting any actual change in the level of prices. Thus, the user of the index should be wary of attaching too much attention to small changes in the index. Since the changes in the index are often blown up to annual rates, their actual significance is sometimes quite misleading. Moreover, short-period changes are often blown up into annual rates, which increases the danger of being misled.

THE QUALITY ADJUSTMENT PROBLEM. Dealing with quality changes in goods and services is one of the most difficult problems faced in compiling a price index, as mentioned earlier. This problem has probably generated more discussion in the literature on consumer prices than any other single statistical issue [4, 9, 12, 21, 26]. There is no entirely satisfactory solution to the problem in a base-weighted index because the "market basket" must be kept reasonably constant, while products and consumption patterns are continually changing.

The Consumer Price Index has achieved a partial solution to the problem. The BLS observes the cost of both the old and the new item when both are available in the market at the same time. The difference between such values is assumed to be a measure of the quality change, and that amount is adjusted out of the price of the new item. With many goods and services, however, both the old and the new (or the old and the improved) are not available at the same time in the market. In such cases, an attempt is made to determine the difference in manufacturers' costs. This difference is then considered a measure of the quality change and is adjusted out of the new price. Quality changes, however, continue to require a great deal of judgment on the part of the statistician. For example, automobile prices must be adjusted yearly to ensure that new model quality improvements are not measured as price increases. The BLS estimates the additional cost associated with producing the change in quality by evaluating

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manufacturing costs and adding the established mark-up. In this way, new features that reflect quality changes are then priced and adjusted out of the index. The difficult question for the BLS, of course, is which new features are quality improvements and which are not. Generally, quality improvements in automobiles have been defined to include "structural and engineering changes that affect safety, environment, reliability, performance, durability, economy, carrying capacity, maneuverability, comfort, and convenience" [5, p. 12].

In practice, however, this definition is of little help in distinguishing quality improvements. Any number of quality changes can affect several of these factors in conflicting ways. For example, an innovation designed to increase economy may reduce performance, durability, carrying capacity, and comfort. As another example, pollution control devices, which *are* defined by the BLS as quality improvements because of their effect on the environment, are considered by many consumers to be exactly the reverse because of their detrimental effects on performance.

THE SEASONAL ADJUSTMENT PROBLEM

The need to adjust the Consumer Price Index and its components for seasonal variation was recognized by the BLS, and seasonally adjusted indexes were first published in 1966. The adjusted series are published only for the components that have been determined to have significant patterns of seasonal variation. Studies have shown that much of the seasonal variation takes place in prices of food, apparel, and private transportation, and that the all-items index is affected slightly by seasonal movement.

Seasonal factors, which may be used to adjust the series, were made available beginning with 1953. The methodology developed by the BLS for seasonal adjustments—the BLS Seasonal Factor Method—is now generally available so that comparable factors can be computed for those series for which no factors or adjusted series are published. The method employed is the traditional ratio-to-moving-average procedure with considerable refinement, and with a means for continuously adjusting the seasonal factors for changes in the underlying seasonal pattern [22].

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THE PRODUCER PRICE INDEX

CHARACTERISTICS

The oldest continually published index of prices is the Producer (formerly Wholesale) Price Index, which is a Laspeyres weighted aggregative index just as is the Consumer Price Index. The index is calculated on a 1967 base and it currently covers about 2800 commodities. Its purpose is to measure both price levels and changes in prices of items at the stage of their most important commercial transaction. Prior to 1978, when the index was called the Wholesale Price Index, it was misnamed, since it has never attempted to measure prices received by wholesale establishments or jobbers. Inter-establishment transfers of goods within firms and goods sold at retail by producers or producer-owned establishments are also excluded from the index.

The Producer Price Index uses base value weights that have been updated since the original base period. The weights used are expenditures for items measured by net value of shipments of producers in particular industries and sectors. Currently, weights are based upon the net selling value of commodities in 1972 as reported in *Census of Manufactures* and *Census of Mineral Industries*, as well as certain other data provided by the Department of Agriculture, Bureau of Fisheries, Bureau of Mines, the Edison Electric Institute, and the Department of Commerce.

A revision was made in January 1976 to incorporate the 1972 census figures on net value of shipments. Prices were updated from 1972 to December 1975, however, in order that the expenditure weights would reflect the most current prices at the time of the index revision. But the base of the index was not changed by the recent revision, so it continues to have a 1967 base. The construction of the base weights for the Producer Price Index is clearly less complex than for the Consumer Price Index. The current policy of the Bureau of Labor Statistics is to revise the base weights every five years in coordination with the Bureau of Census's publishing of new censuses of manufacturing and mining.[6] The BLS is currently engaged in an extensive revision of the Producer Price Index that is scheduled to be completed in 1984. (See Early [6, pp. 7-15] for a detailed discussion of the

[6] For complete descriptions of methods and recent revisions, see [2, 28].

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planned revision.) The revision program is designed to eliminate multiple counting of price changes, to expand the coverage of production, to increase the sample sizes of various producer and product groups, to minimize the distortion in the index attributable to the discrepancies between list and transactions prices (this distortion will be discussed subsequently), and to improve sampling techniques in general. After the revision program is completed, the Producer Price Index will include industry input price indexes, industry output price indexes, detailed commodity indexes and stage-of-processing indexes. The All Commodities Index will be phased out. Although the revision program will not be completed until 1984, the BLS will publish the results as they become available. The BLS at present publishes, in addition to the stage-of-processing indexes and the All Commodities Index, component indexes by durability of product and by industry groups and subgroups. In the stage-of-processing category, separate indexes are constructed for crude materials, intermediate materials, consumer finished goods (at the wholesale level), and producer finished goods. These indexes enable analysts to isolate major price changes by stage of production. The "durability of product" classification facilitates price comparisons between durable and nondurable goods. Industry subgroup indexes carry this breakdown further and permit detailed comparisons of price movements. Since prices are obtained by industries or sectors, the Producer Price Index has no area breakdown, as does the Consumer Price Index.

Table V shows the relative weights of items included in the Producer Price Index by industry and by stage of processing both before and after the recent revision. As explained above, these weights are based upon net value of shipments reported in the 1972 censuses. Detailed relative weights are available by individual item from the BLS [29].

At their lower stage of processing, many of the commodities covered by the Producer Price Index are not affected as acutely by quality change as are consumer goods and services. Industrial goods such as machinery and other producer-finished items are, of course, subject to rapid technological change and quality improvement. However, since the index excludes services and since commodities are priced before the final stages of processing and

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Table V

RELATIVE IMPORTANCE OF COMMODITIES INCLUDED IN THE PRODUCER PRICE INDEX, DECEMBER 1975

BY INDUSTRY

	1963 weights	1972 weights
Farm products	11.28	8.40
Processed foods and feeds	16.55	14.37
Textile products and apparel	5.76	5.78
Hides, skins, leather, and related products	1.08	.76
Fuels and related products, and power	10.39	10.34
Chemicals and allied products	6.55	7.17
Rubber and plastic products	2.02	2.80
Lumber and wood products	2.54	2.23
Pulp, paper, and allied products	4.75	5.28
Metals and metal products	13.45	13.00
Machinery and equipment	11.32	11.84
Furniture and household durables	2.86	3.44
Nonmetallic mineral products	3.05	2.82
Transportation equipment	6.26	8.61
Miscellaneous products	2.14	3.19

BY STAGE OF PROCESSING

Crude materials for further processing	12.31	11.33
Foodstuffs and feedstuffs	7.84	6.97
Nonfood materials except fuel	3.18	3.15
Crude fuel	1.29	1.21
Intermediate materials, supplies, and components	47.28	47.11
Materials and components for manufacturing	25.62	25.59
Materials and components for construction	8.45	7.94
Processed fuels and lubricants	4.53	4.85
Containers	1.58	1.39
Supplies	7.09	7.35
Finished goods (including raw foods and fuel)	40.41	41.56
Consumer goods	31.47	29.71
Producer finished goods	8.94	11.85

handling, the price changes associated with quality improvements are somewhat easier to measure.

The pricing methodology used in the Producer Price Index has been subject to considerable criticism. Price data are collected monthly, primarily from mail questionnaires filled out by representatives of producing companies. Since January 1967, respondents generally have been asked to report the prices in

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effect on the Tuesday of the week in which the 13th of the month falls. The BLS attempts to get transactions prices, not list prices, whenever possible, and respondents to the mail questionnaire are asked to disclose either net prices of commodities or to provide information on all available discounts. Response to the questionnaire, however, is voluntary and even though respondents are assured that their information will be kept confidential, prices of some items are not provided. In these cases, list or spot prices quoted by manufacturers or trade associations are used as substitutes. The substitute data can be misleading, as noted earlier in the second part of the monograph, because they ignore discounts and often do not reflect prices at which commodities are actually traded. The differences between published and contract prices can, of course, be quite significant, because producers often delay publishing price reductions. This problem was the source of the severe criticism of the Wholesale Price Index (now the Producer Price Index, as noted earlier) by Stigler and Kindahl [24] in 1970. Greater inclusion of discounts from the survey respondents since that time has made their study's conclusion—that the Wholesale Price Index may overstate the level of industrial prices in periods of softening economic activity—less appropriate, but it probably still cannot be dismissed completely.

The questionnaire technique itself has a major theoretical shortcoming, however, and is therefore far less satisfactory than the sampling technique—i.e., actual pricing of items by field workers—used for the Consumer Price Index. Price information, particularly information relating to discounts and/or add-ons, is often quite sensitive, and firm representatives in such circumstances may be less than candid in their survey responses.

SEASONAL ADJUSTMENTS AND SAMPLING ERRORS

The BLS does not publish seasonally adjusted indexes for the detailed commodity groupings of the Producer Price Index. However, it does provide seasonally adjusted monthly percentage changes. Seasonally adjusted index numbers are published for stage-of-processing indexes.

Estimates of sampling error for the Producer Price Index are not produced by the BLS. The sample employed for the index does not lend itself to the measurement of sampling error, since it is selected purposively rather than on a random sampling basis.

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Also, the number of reporters from whom price information is obtained is very small for many of the individual commodities, and the methods of aggregation used—by industry, durability of product, and stage of processing—result in heterogeneous groupings of individual items. Although the sample is already very large, an even larger sample would be needed, in view of the diversity of products covered, in order to develop reliable estimates of sampling error.

THE IMPLICIT DEFLATOR FOR GNP

The methodology of the GNP Deflator was discussed in general terms in the first part of this monograph. Since the index is not derived from direct price measurements as are the other major indexes, its values depend upon the indexes already discussed, as well as upon other indexes. The consumer expenditure component of GNP is adjusted for price change—i.e., deflated—by dividing each category of consumer spending by the appropriate index of consumer prices. Business expenditures for capital equipment, raw materials, or semi-finished goods are deflated by the applicable index of producer prices. Thus, the Consumer Price Index and the Producer Price Index figure prominently in the determination of the Deflator. In addition, indexes of construction costs and import prices are among those used to deflate other components of GNP.

As the composition of Gross National Product changes, so does the relative importance of the various indexes used to deflate the components of GNP. The components of GNP in any particular period are, in effect, weights for determining the GNP Deflator. For example, if business inventory investment in consumer finished goods increases in a given period while consumer spending tapers, those indexes of producer prices applicable to consumer finished goods receive increased weight in the Deflator and the indexes of consumer prices receive less. Thus, since the components of GNP function as implicit current period expenditure weights, the GNP Deflator is, in essence, a Paasche-type index.

An example of an individual item may help to illustrate the Deflator concept. Consumer expenditures for color television sets

would be classified in the personal consumption expenditures component of GNP. The price index for color televisions is one of the elements of the Consumer Price Index. Total expenditures for the television sets in year 2 can be represented by p_2q_2, where p_2 is the price and q_2 is the quantity purchased. The expenditure is deflated by the price index (a Laspeyres type), p_2q_1/p_1q_1, where year 1 is the base. For the individual item, this reduces to the price relative, p_2/p_1. The deflation expresses the expenditure in terms of dollars of the base year,

$$p_2q_2/(p_2/p_1)=p_1q_2.$$

If the current expenditure is divided by the deflated expenditure, an index is obtained,

$$I_{1\,2}=p_2q_2/p_1q_2,$$

which is a Paasche-type index, and is an implicit deflator for consumer purchases of color television sets. Since the illustration deals with a single item, the result is still equivalent to the original price relative, p_2/p_1, but that equivalence is not true of the index as an aggregative measure.

Deflated GNP, for example, is obtained by dividing each item or class of items by the appropriate index,

$$\Sigma\,[p_2q_2/(p_2q_1/p_1q_1)]=\Sigma p_1q_2.$$

Since the Implicit Deflator results from dividing current dollar GNP by the deflated amount,

$$I_{1\,2}=\Sigma p_2q_2/\Sigma p_1q_2,$$

the index is a Paasche-type weighted aggregative index.[7]

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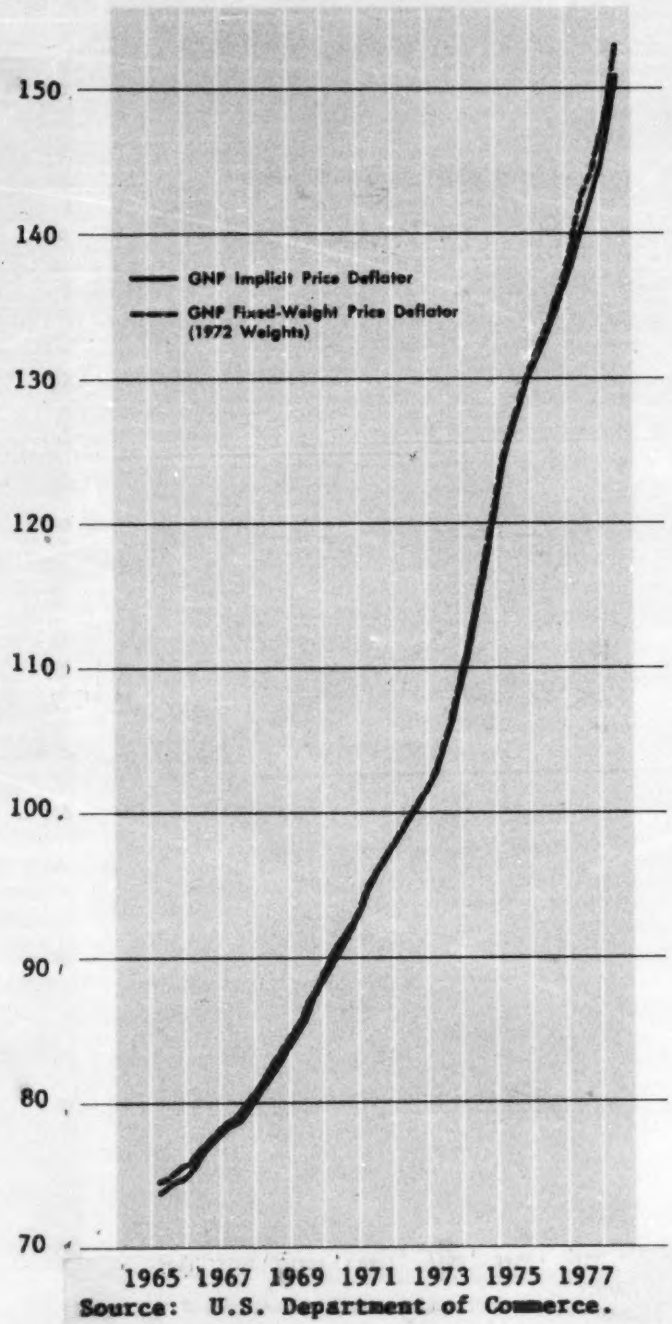
[7] For further discussion and additional references regarding the GNP Deflator methodology, see [15].

Chart V

PRICE DEFLATORS

1972=100 (Quarterly Data, Seasonally Adjusted)



Source: U.S. Department of Commerce.

Analyses of price changes are not as simple with current-weighted indexes as with fixed-weighted ones, because continuous shifts in the "market basket" mean that values of the index from one period to the next actually compare different things. Moreover, each value of the index compares current prices only to base period prices, and, therefore, successive values of the index do not provide a consistent series. A fixed-weighted index for GNP probably provides a better means of short-term comparison of price changes applicable to the nation's total output. Such an index (with 1972 quantity expenditure weights) is currently published by the Department of Commerce. The two indexes are compared in Chart V. Since the two series are similar, it appears that there is very little difference between them when the actual index numbers are plotted, but quarterly changes can differ significantly.

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